Report Number: QR-10158.02
Report Period: 22 May 1994
through 22 August 1994

CONTRACT TITLE AND NUMBER:

InP Solar Cell Development on Inexpensive Si Substrates
N00014-94-C-2030

CONTRACTING AGENCY:

Naval Research Laboratory
Bldg. 71 Code 6615
4555 Overlook Ave. S.W.
Washington, DC 20375

CONTRACTOR'S NAME AND ADDRESS:

Spire Corporation
One Patriots Park
Bedford, MA 01730-2396

Contract Period: 22 February 1994 to 22 February 1995

STATUS:

Table I shows the current program schedule.

Table I *Program schedule.*

Tasks	Feb 94	Mar 94	Apr 94	May 94	Jun 94	Jul 94	Aug 94	Sep 94	Oct 94	Nov 94	Dec 94	Jan 95	Feb 95
1 Optimize Emitter		X	X	X	X	X	X	X	X	X	D1		
2 Process Technology							X	X	X	D2			
3 NRL Small Cells							X	X	D3				
4 Dev. InP/Si Growth		X	X	X	X	X	X	X	X	D4			
5 Si Wafer Thickness				X	X	X	X	X	X	D5			
6 Large Cell Demo										X	X	X	D6

Legend:
S - Task started
X - Task ongoing
E - Task expected to end
D# - Expected cell delivery

Deliveries:
D1 - > 48 1 x 1 cells, 240 DLTS diodes
D2 - > 6 1 x 1 cells
D3 - 2 wafers 0.5 x 0.5 cells, 60 DLTS
D4 - > 20 1 x 1 cells
D5 - > 18 1 x 1 cells
D6 - > 100 2 x 2 cells, > 4 2 x 4 cells

Task 1 - Optimize Emitter/Base Dopants - In Phase I, P/N InP control cells on InP wafers had substantially less photocurrent than N/P InP counterparts. The suspected culprit was diffusion of the zinc dopant, creating a thicker emitter than intended. Secondary Ion Mass Spectroscopy (SIMS) data taken during this report period confirmed this hypothesis. The primary findings are:

- P/N InP cells were grown with both 200 and 400Å thick emitters; however, the SIMS profiles (Figure 1) showed both cells have virtually the same junction depth, or ~2000Å thick emitters, about 5 to 10X larger than expected. The excess Zn is diffusing in from the 3000Å thick P^{++} $In_{0.53}Ga_{0.47}As$ contact layer on top of the cell.

- P/N InP cells on InP wafers or Si wafers had virtually the same diffusion profiles (Figure 2), with only a barely noticeable enhancement of the Zn diffusion in higher defect density InP/Si wafers, which is good news.

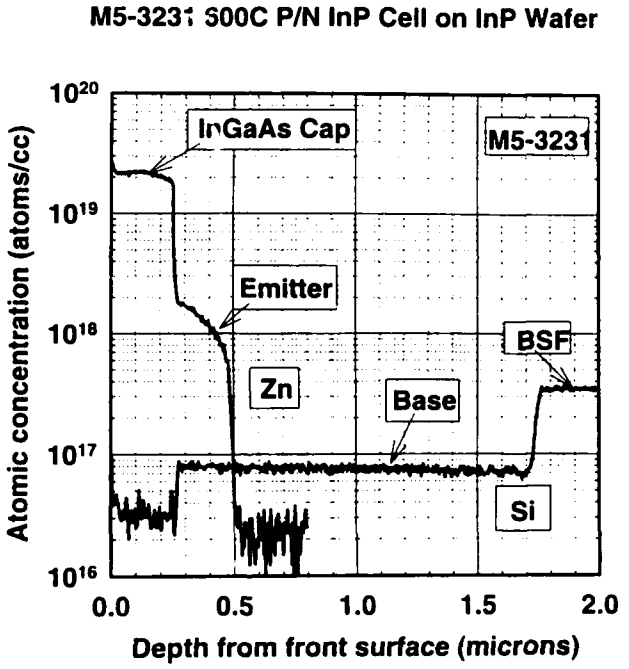

Figure 1 *SIMS profile of zinc diffusion in P/N InP cells on InP wafers. Two zinc profiles from two different cells, one with a grown 250Å Zn-doped emitter, and one with a 500Å emitter, resulted in virtually identical profiles, one of which (run 3231, 250Å emitter) is shown. Zn diffusing in from the heavily doped InGaAs contact cap dominates the grown emitters, creating a ~0.2 μm junction in each layer despite the different emitter growth times.*

Task 2 - Optimize P/N Cell - Because of the zinc diffusion out of the InGaAs contact cap, the emitter is thicker than originally planned. Therefore, 2 x 4 cm cell photomask required for this program was redesigned to work best with these thicker emitters. Delivery of masks is slated for September.

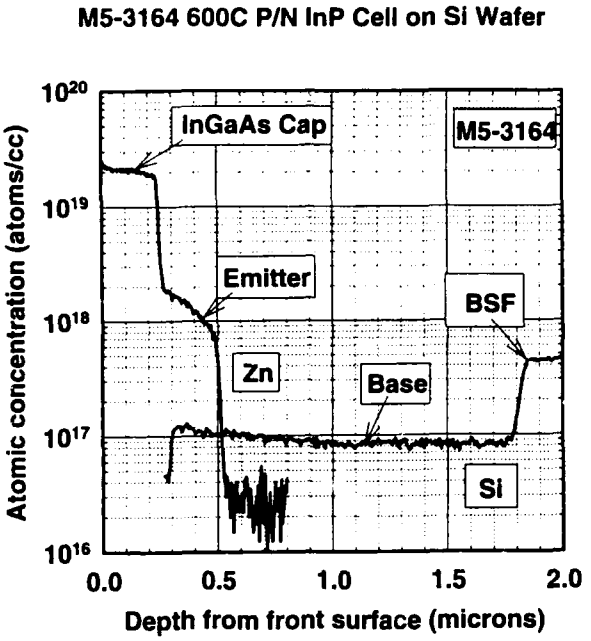

Figure 2 *Zinc SIMS profiles in P/N InP cells on Si wafer; differences between this cell on a Si wafer and a cell grown on an InP wafer (Figure 1) are barely noticeable. We were concerned that the Zn would diffuse more in the InP/Si due to the higher level of defects in InP/Si versus InP/InP wafers; however, this is fortunately not the case.*

Task 3 - Produce Quantities of Small Optimized N/P and P/N Cells - These wafers were grown and are being processed. They will be ready for delivery in October 1994.

Task 4 - Optimize the InGaP Grading Layer - A set of wafers are being grown to compare InP cells on both 200Å and 2 μm thick GaAs layers on the Si wafer. The thinner GaAs layer is a quicker growth, and has resulted in much better surface morphology than the past Phase I material. Before we commit to using these thin layers, the electrical performance of cells made in this material should be evaluated against material with thicker GaAs layers.

Task 5 - Si Substrate Thickness - This task is scheduled to be finished in November 1994.

Task 6 - Production of Large Optimized Cells - This task is scheduled to begin in December 1994.

Steven J. Wojtczuk
Principal Investigator

DISTRIBUTION LIST

Administrative Contracting Officer
Naval Research Laboratory
4555 Overlook Ave, SW
Wasington, DC 20375-5326

Director
Naval Research Laboratory
Attn: Code 2627
Washington, DC 20375

Defense Technical Information Center
Building 5, Cameron Station
Alexandria, VA 22304-6145

Department of Defense
Ballistic Missile Defense Organization
Attn: T/IS
7100 Defense Pentagon
Washington, DC 20301-7100